BIOLOGY AND ECOLOGY OF *MAGICICADA SEPTENDECIM* (L.) (HEMIPTERA: CICADIDAE)[1]

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Abstract The emergence of Brood 11 of the periodical cicada in Connecticut in 1962 provided an opportunity to add some data on the biology and ecology of this insect. Nymphal patterns, the effects of soil temperature, and bird predation are discussed in relation to emergence. Also noted is a prolonged period of emergence, daytime adult transformation, and distribution in Connecticut.

Brood 11 of the periodical cicada emerged in central and south central Connecticut during late May and early June of 1962. Some observations of this insect were made in an orchard in Middlefield, Connecticut, where a heavy population occurred. An estimate of this population was difficult, since in 1958 the orchard soil was treated with an insecticide to reduce the nymphal population. Even so, in a cage covering 9 square feet under a mature apple tree, 386 nymphs emerged. The concentration of nymphs in the orchard was greater than in adjacent woodlands.

Three species of 17-year cicadas are recorded for Brood 11, but only *Magicicada septendecim* (L.) is recorded from Connecticut (Alexander and Moore, 1962). More than 16 quarts of adult specimens were collected in Guilford, Middlefield, Meriden and Southington, Connecticut to check the species. Specimens thought to be *M. septendicula* Alexander and Moore were sent to Dr. Thomas E. Moore, of the Museum of Zoology, University of Michigan. Dr. Moore identified these specimens as *M. septendecim.* (L.).

NYMPHAL CHARACTERS

Nymphs were collected at intervals to determine occurrence of any changes in nymphal color patterns that might be useful for more reliability of prediction of emergence. Color changes of value in this connection (figure 1) were based upon two obvious dark spots on the prothoracic dorsum and two less obvious and lighter spots on the tylus. Since nymphal collections were made at irregular intervals, the time that these color changes occur in regard to emergence can only be estimated. The darkening of the prothoracic spots occurs gradually, and appears to be complete (black) at least 3 to 4 days before emergence. The pigmentation on the tylus occurs

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at least 1 to 2 days before emergence. Hundreds of nymphs were observed emerging to transform and all had total black prothoracic spots, and tylus spots varying from brown to black. Emergence cannot be expected until after these color changes have taken place.

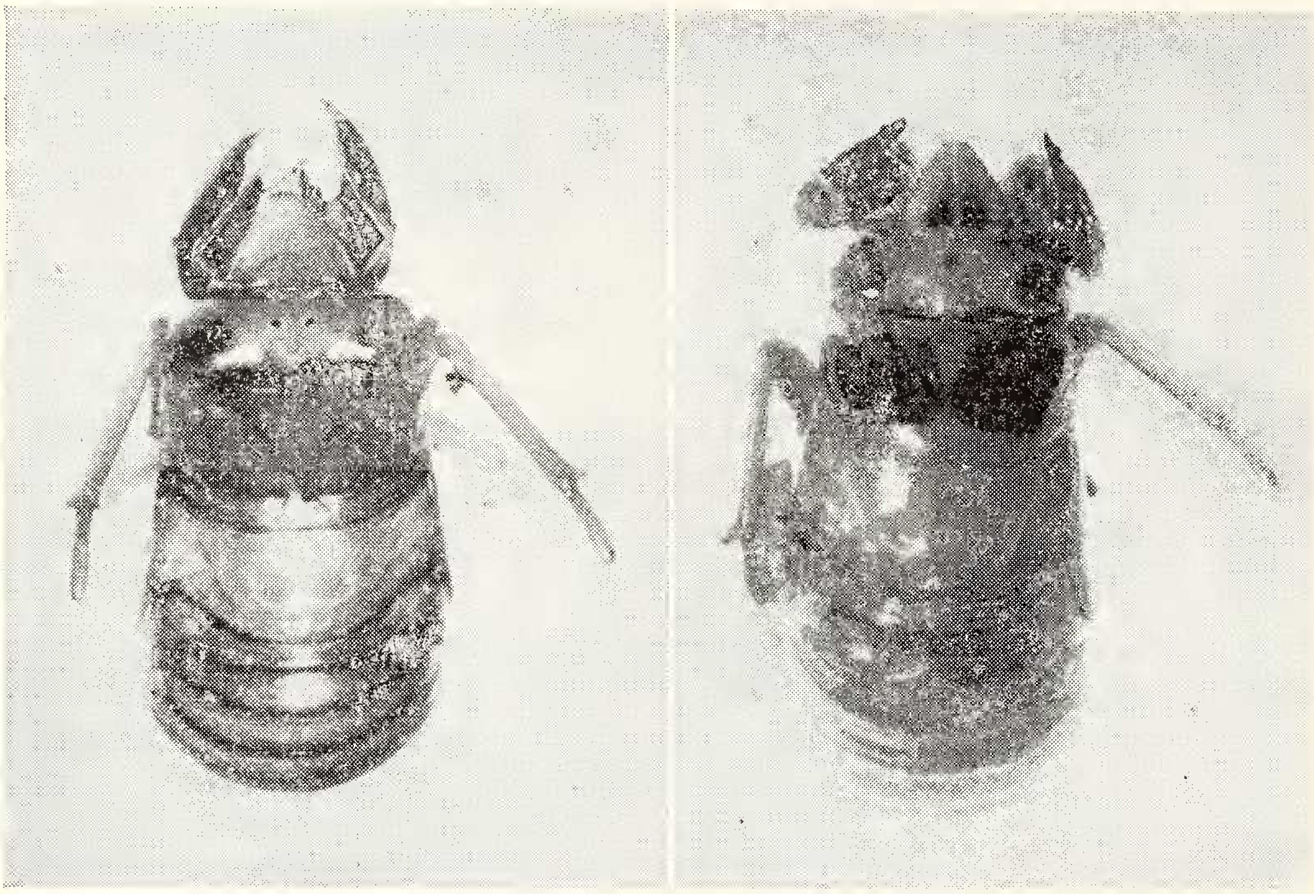

Figure 1. Nymphal color pattern changes are useful in determining cicada emergence. Emergence does not occur until after the dark spots appear on the prothoracic dorsum and tylus, as shown in the nymph on the right.

Effects of Soil Temperature

Several accounts in the literature indicate soil temperature affects emergence (Marlatt, 1907; Krumbach, 1917). Beamer (1931) noted emergence (of *M. cassanii?*) in a glen, protected from the wind and exposed to the sun, occurred several days before emergence in dense shade or uplands.

Soil temperatures were recorded on the south (sunny) and north (shady) side of an apple tree (table 1). Soil temperatures of the southern exposure are higher, with the differences less pronounced at lower depths. The first emergence in the orchard took place under the south portion of the trees. This was evident on the first and second nights of emergence, but less apparent on the third night.

The later emergence of adults from adjoining wooded areas also indicates the effects of soil temperature. Emergence from these areas was about 10 days later than emergence in the adjacent orchard. The soil temperatures in the wooded areas were considerably lower than those in the orchard (table 2).

Table 1

DATE	TIME	SOUTH DEPTH IN CM.				TIME	NORTH DEPTH IN CM.			
		25	50	120	180		25	50	120	180
May 17	10:30 A.M.	82	71.5	60	58	10:45 A.M.	76	70.5	60	55.5
May 21	12:40 P.M.	95	78	71	66	12:55 P.M.	88	81	69	68
May 25	12:15 P.M.	96	78	71	66	12:55 P.M.	84	68	63	60
June 1	11:50 A.M.	—	88	85	72	12:10 P.M.	—	76	67	65

Comparison of soil temperatures (degrees F.) under the south (sunny) and north (shady) side of an apple tree. Emergence occurred first under the south portion of the tree.

Most accounts of cicada emergence record heavy emergence over a period of one to three nights. However, in the Middlefield orchard, heavy emergence took place nightly from June 1st until 9–10th. Emergence started in May 27th, and continued at a low level until May 30th, when moderate numbers emerged. Counts from cages placed throughout the orchard will give some indication of this trend (table 3).

Table 2

TIME	ORCHARD DEPTH IN CM.				TIME	WOODS DEPTH IN CM.			
	25	50	120	180		25	50	120	180
12:30 P.M.	96	88	85	82	12:55 P.M.	66	65	62	59

Soil temperatures taken on June 2nd on the south side of an apple tree and in adjacent woods. Emergence, already started in the orchard, did not start for another week in the woods.

Table 3

DATE OF COLLECTION	NUMBER OF CICADAS
June 6	938
June 8	345
June 11	369
June 14	42
June 18	96
June 20	11
June 21	4
discontinued	

Cage record of cicada emergence.

Emergence of large numbers of cicadas over a relatively short period of time may be due to a variety of conditions of which soil temperature is only one. Soil temperature recorded prior to and during emergence are included (table 4). On May 30th, when these recordings were made, emergence was the heaviest to date, but larger numbers emerged in succeeding nights.

Table 4

TIME	AIR TEMP.	DEPTH IN CM.			
		25	50	120	180
3:30 P.M.	80.5	84	82	69	64
6:30 P.M.	80.5	—	78	70	66
7:30 P.M.	74	—	72	69	66
9:30 P.M.	68	—	76	67	65

Soil and air temperatures taken under an apple tree prior to and during emergence on the first evening (May 30) when cicadas emerged in numbers.

Beamer (1931), in studies conducted in Kansas, noted the first adults to appear emerged early in the morning, but this was not observed in Middlefield. On June 6th, in the second week of emergence, transformation was observed throughout the day. At 12:30 P.M., 23 cicadas were counted in a three foot section of an apple tree trunk. Of these, 17 were nymphs, and 6 were transformed or transforming adults.

BIRD PREDATION

On May 17–30th, the period before peak emergence, the striking effects of bird predation (primarily blackbirds) was noted. During this period the only evidence of emergence was nymphal exuviae and adult fragments. Beamer (1931) noted that bird predation took place in the early morning hours, with a conspicuous lack of bird activity later in the day. This pattern was again evident in Middlefield.

Alexander and Moore (1962) in their excellent account of 17 and 13-year cicadas relate the effects of bird predation to synchronous emergence. It is noteworthy that synchronous emergence is of advantage in reducing the effects of bird predation on the population. Synchronous emergence is being favored by the heavy selective pressure by birds on early emerging forms.

DISTRIBUTION IN CONNECTICUT

Marlatt (1907), in a distribution map of Brood 11, indicates that this brood occurs throughout the eastern half of Connecticut. The map of Britton (1911) outlines the infestation as it occurred in 1911, and this corresponds to the infestation observed in 1962. The cicadas occur almost wholly in the higher elevations, primarily on a series of ridges throughout central and south central Connecticut. This is coincident with reports that *M. septendecim* is primarily found in upland woods (Beamer, 1931, Dybas & Lloyd, 1962). In Connecticut, the lowlands and slopes once cleared for agricultural purposes have become reforested, yet there appears to be no noticeable migration of cicadas into these areas. The periodical cicada has a wide range of host plants, and the deciduous flora on the ridges and the valleys does not differ to any great extent. Restriction to the upland habitat by *M. septendecim* (at least in Connecticut) is not due to displacement by *M. cassanii.*

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FREE FAT AND GLYCOGEN DURING METAMORPHOSIS OF *MUSCA DOMESTICA* L.

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Abstract During the metamorphosis of the house fly, both glycogen and fat are used as direct energy sources. At 25°C., the percentage of glycogen decreases from 0.99 in the prepupa to 0.34 in the 2-day pupa. It increases to 0.54 during the next 24 hrs. at the expense of fat and then diminishes to 0.28 in the newly emerged adult. The percentage of fat increases from 8.72 in the 6-day larva to 12.39 in the 1-day pupa. A loss of 2.8% occurs at the time glycogen increases and another loss of 2.6% occurs during the change from the 4-day pupa to the adult. These decreases are greater than required for the production of glycogen and for the loss of fat in the puparium and pupal skin on emergence.

Fats and glycogen are important sources of energy during the metamor-